PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.: B 62 d // B 66 c

COMPLETE SPECIFICATION

Improvements in Tower Cranes

We, PRIESTMAN BROTHERS LIMITED, a British Company of Holderness Engineering Works, Hedon Road, Hull, Yorkshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In order to give tower cranes a certain amount of mobility on civil engineering sites, their bed plates which support their tower structures are sometimes mounted on flanged wheels which run on rails laid on the site. The rails have to be laid and maintained perfectly flat to avoid any possibility of the high tower crane overbalancing. This is a problem on building sites where excavations may lead to subsidence. Another disadvantage is that the rails cover ground which cannot be overrun by other vehicles and in any case only provide a very small amount of manoeuvrability for the cranes.

In accordance with the present invention, the bed plate of a tower crane is mounted on crawler tracks the frames of which, adjacent to the front and rear on each side of the bed plate, are raised and lowered relatively to the bed plate under the control of a master levelling device which ensures that when the crawler tracks follow the contours of the ground the bed plate is maintained substantially horizontal.

With this arrangement the crane has the usual mobility of crawler mounted plant without the need for laying permanent rails.

There may be separate front and rear crawler tracks on each side of the bed plate, each supported on its own frame. The crawler frames on each side may then be interconnected by a pivotal link and will be raised and lowered relatively to the bed plate independently.

For a smaller crane a single crawler track supported by a rigid frame may be provided on each side of the bed plate, the frames tilting independently of one another under the control of the master levelling device.

Preferably, however, there is a single crawler track on each side of the bed plate, each track being supported by a flexible frame. The front and rear parts of each frame are independently suspended from the bed plate and may be interconnected by a pivotal link.

The crawler frames are preferably suspended from the bed plate by means of beams which are pivotally connected to the bed plate and are rocked about their pivotal connections to raise and lower the parts of the crawler frames under the action of four separate levelling rams each of which acts between the bed plate and one of the beams. The supply of fluid to and the exhaustion of fluid from the rams, which are preferably double acting is under the control of the master levelling device which ensures that the bed plate remains substantially horizontal whilst the crawler tracks engage the ground firmly at the front and rear and take their share of the weight of the crane even on uneven ground. The two beams through which the frame parts at the front of the bed plate on each side are suspended and the two beams through which the frame parts at the rear of the bed plate on each side are suspended, preferably extend transversely across the bed plate and are all pivotally mounted to the bed plate at a common central pivotal axis extending longitudinally of the bed plate. In this case the four adjusting rams are situated one at each corner of the bed plate

[Price

where they engage the beams with a considerable lever arm. We find however that it is sufficient to give each of the rams a maximum stroke of 6 inches.

In order to provide a sufficiently narrow track width for transporting the crane by road and for travelling on comparatively level ground, whilst providing a wide track width to give the crane good lateral support when it is working, the beams, when they extend across the bed plate, are preferably extendable so that the crawler tracks and frames can be moved laterally outwards away from the bed plate to a new working position or range of positions.

Thus each beam may be made in two telescopic parts: a hollow beam box which is pivotally connected to the bed plate and is acted upon by its corresponding levelling ram, and a beam axle which slides within the box and supports its corresponding crawler frame part. The extension of the beams may be controlled by means, for example, of subsidiary rams each of which is connected between the bed plate and one of the crawler frames. When there is one flexible crawler frame on each side, formed in two parts which are interconnected by a pivotal link, the subsidiary rams may act on the pivotal links.

When the beams are telescopically extendable in this way, the beam boxes preferably extend substantially the full width of the bed plate, even though they are pivotally connected to the bed plate at its centre, so that sufficient support is provided for the beam axles within the beam boxes even when the axles are extended. In this way the beams at the front and rear of the bed plate act with a scissor action under the control of the levelling rams.

The lateral extension and retraction of the crawler frames and tracks requires the crane to be supported other than on the crawler tracks during adjustment. For this purpose elephant feet may be provided at the four corners of the bed plate for supporting the crane temporarily while the beam axles are extended or retracted. The elephant feet are preferably mounted on the inner ends of the beam boxes, that is the ends remote from those from which the axles extend and support the crawler frames. The feet are brought into use by screwing them downwards into contact with the ground and subsequently rocking the beam boxes in the appropriate direction.

The master levelling device may comprise a chamber which is loosely universally mounted so that it can tilt in all directions on the bed plate and the inner bottom surface of which is inclined upwards and outwards in all directions from the centre of the bottom, a spherical ball which rests in the bottom of the chamber, and a number of micro-switches symmetrically arranged around the upright central axis of the chamber; the arrangement being such that when the bed plate is level the spherical ball rests in the centre of the base but when the bed plate tilts in one direction or the other the chamber tilts relatively to the bed plate in the same direction and the ball rolls outwards from the centre of the base and the added weight of the ball on that side of the chamber causes the micro-switch or switches to be operated in such a way that a levelling means actuated by the switches causes the crawler track frames to be raised and lowered relatively to the bed plate as necessary to level the bed plate. When the levelling means are four rams at the four corners of the bed plate, only four micro-switches are necessary each controlling the fluid supply to a different one of the rams.

The invention is applicable to tower cranes of the type in which the tower structure is mounted rigidly on the bed plate from which the crawler track frames are suspended and a slewing, possibly horizontal, jib is fitted to the top of the tower structure. Alternatively however the crane may be such that the main bed plate carries above it through a turntable a subsidiary upper bed plate on which is mounted the tower structure which carried a luffing jib and one example of a tower crane of this kind constructed in accordance with the present invention is illustrated in the accompanying drawings in which:

Figure 1 is a side elevation of the crane;

Figure 2 is a side elevation of the crane chassis on a larger scale;

Figure 3 is a diagrammatic plan view of the chassis;

Figure 4 is a section taken on the line IV—IV in Figure 3;

Figure 5 is a diagrammatic end view of the chassis showing the crawler tracks in their laterally retracted position;

Figure 6 is a view similar to Figure 5 but showing the crawler tracks being extended;

Figure 7 is a view similar to Figures 5 and 6 but showing the crane standing on ground of different traverse inclination,

Figure 8 shows in diagrammatic side elevation how the crawler tracks adjust themselves to the longitudinal inclination of the ground whilst maintaining the bed plate level;

Figure 9 is a central vertical section with parts in elevation of a master levelling device mounted on the bed plate;

Figure 10 is a plan view of a mounting plate for the levelling device; and,

Figure 11 is a diagrammatic electrical and hydraulic control circuit by means of which the master levelling device controls the levelling of the bed plate.

The crane consists of a superstructure 12 and a tower structure 13 both carried on an

upper subsidiary bed plate 14 which is mounted through a turntable 15 on a lower main bed plate 16 carried on a crawler chassis 17. A jib 18 is luffed by means of a rope 19, is pivotally mounted to the upper end of the lower structure 13 and carries a crane hook 20 which is raised and lowered by means of a hoist rope 21. The ropes 19 and 21 are taken in by means of rope drums mounted in the superstructure 12.

As shown more clearly in Figures 2, 3 and 4 the crawler track 22 on each side of the bed plate 16 runs over a series of guide wheels 23, under a series of bogey wheels 24 and around end wheels 25 and 26, all of which are supported on a frame formed by separate front and rear parts 27 which are interconnected by a pivotal link 28. Each track 22 is driven by means of the wheel 26 which in turn is independently driven from a motor 29 through a reduction gear 30, a chain 31 and a sprocket on the axle of the wheel 26. Since the crawler tracks 22 are independently driven by their own motors, steering is provided by driving the wheels 26 for the two tracks at different speeds.

The front and rear parts 27 of the crawler frames are each suspended from the bed plate 16 by means of transverse beams each consisting of a beam box 32 and abeam axle 33 which slides telescopically within the beam box. Each pair of beam boxes 32 at both the front and rear of the bed plate 16 extend fully across the width of the bed plate one in front of the other. At their outer ends the beam axles 33 have a cranked portion 34, each pair of axles 33 being cranked in opposite directions so that the crawler frames are supported symmetrically by means of part spherical stub axles 35 which fit into corresponding bushes 36 in the frame parts 27.

Each of the beam boxes 32 has a central upwardly extending ear 37 which is pivotally mounted between flanges 38 of the bed plate by means of a pin 39, all the boxes being pivotally mounted about a common central longitudinal axis of the bed plate 16. At its end through which its corresponding beam axle 33 extends, each beam box 32 is connected to the adjacent corner of the bed plate 16 through a double acting hydraulic ram the cylinder 40 of which is pivotally mounted to the bed plate and the rod 41 of which is pivotally mounted to the corresponding beam box 32. The extension and retraction of each ram causes the corresponding beam box and axle to rock upwards and downwards relatively to the bed plate so that the corresponding part 27 of the crawler frame at that corner of the bed plate is lowered or raised relatively to the bed plate. The supply of oil to the four rams 40 is controlled by a master levelling device so that the bed plate 16 and hence the bed plate 14 always remain horizontal irrespective of the inclination of the ground. This will be clear from Figures 7 and 8.

As illustrated most clearly in Figures 5, 6 and 7, each beam box 32 is provided at its end remote from that through which the corresponding beam axle 33 extends, an elephant foot 42 which can be screwed downwards into engagement with the ground. This is useful for assisting in supporting the weight of the frame when the crane is stationary in a working position. However, the full weight of the crane can be taken on the elephant feet if the rams are retracted sufficiently to raise the crawler tracks 22 off the ground. When this has been done, the crawler tracks 22 and their frames can be moved laterally away from or towards the bed plate 16 by extending or contracting subsidiary rams 42' which act between a bracket 43 beneath the centre of the bed plate 16 and the corresponding one of the pivotal links 28. During this movement the beam axles 33 slide freely in their beam boxes 32. After the crawler tracks have been moved laterally to a new working position, the weight can be taken on the crawler tracks again by extending the rams once more. In the extended position shown in full lines in Figure 6, and shown in Figure 7, the effective wheel base width of the crane is considerably greater than in the retracted position shown in Figure 5 and in chain dotted lines in Figure 6, so the crane has greater stability. In effect the extended crawler tracks act as outriggers.

The master levelling device and the associated electrical and hydraulic circuitry necessary for ensuring that the four rams which control the rocking of the beam boxes 32 relatively to the bed plate 16 so that the bed plate 16 is at all times kept substantially horizontal even when the crane is travelling, is illustrated in Figures 9, 10 and 11. Situated at any convenient point on the bed plate 16, on a resilient pad 44, is a housing 45 having a pillar 46 which supports through a loose ball and socket joint 47 a chamber 48. The bottom inner surface 49 of the chamber 48 is inclined conically upwards and outwards from the centre of the chamber at an angle of conicity very slightly less than 180 degrees. A spherical metal ball 50 rests within the chamber 48 on its bottom surface 49 and is free to roll about in the chamber. A mounting plate 51 which is also carried by the pillar 46 carries four symmetrically arranged micro-switches 52 each of which has a screw threaded stem 53 which extends upwards through a radially elongated slot 54 in the plate 51 and is secured in position by means of lock nuts 55. A plunger 56 for each micro-switch 52 extends up through the corresponding stem 53 adjacent to the bottom of the chamber 48. Between each adjacent pair of micro-

switches 52 an abutment screw 57 extends outwards through one of four holes 58 in the plate 51 and the height of each screw 57 is adjusted by means of lock nuts 59.

The chamber 48 is only allowed a very small freedom to tilt about its ball and socket joint 47, the ultimate freedom being determined by the adjusting screws 57. In use, the chamber is initially level so that the ball 50 rests in the centre of the base 49. If the crane moves over uneven ground so that the crawler tracks and bed plate start to tilt in one direction, the chamber 48 tilts with the bed plate until part of the base of the chamber tilts through the horizontal in one direction and rests lightly on the plunger 56 of one or two of the switches 52. The ball 50 then rolls away from the centre of the chamber 48 and the added weight of the ball on one side of the chamber causes it to operate the micro-switch or switches on which it previously only rested. This causes the fluid supply circuits for the levelling rams to be adjusted accordingly so that the rams extend or contract relatively to one another and cause the bed plate to remain substantially horizontal. As the bed plate returns exactly to its horizontal orientation, the ball 50 rolls back to the centre of the chamber 48 thus restoring equilibrium once more.

The chamber 48 contains a damping fluid 60a the viscosity of which determines the speed with which the ball 50 rolls in the chamber 48 and hence determines the speed of response of the device. Adjustment of the stems 53 along the slots 54 may also be used to adjust the speed of response of the device since this will effect the distance which the ball 50 will have to roll before the moment of the assymmetrical weight of the chamber and ball is sufficient to operate the corresponding micro-switch.

As shown in Figure 11, each micro-switch 52 is associated with a diagonally opposite pair of the levelling rams which, and the switches and valves associated with which, are referred to as A, B, C, and D taken in order around the bed plate 16. Each micro-switch 52 includes two pairs of two way switches each pair being associated with one of the rams. An electrical voltage supply is provided through conductors s to the centre moveable contact in each switch. The two stationary contacts of each switch between which the moveable contact moves to and fro lead to one and the other respectively of the two solenoids of a two way valve 60 through which oil is supplied along lines 61 to the cylinder 40 of the corresponding ram. The conductor from one of the stationary contacts of each switch is designated u and the other is designated d representing "up" and "down". These conductors lead to corresponding up and down solenoids of the corresponding valve 60, the arrangement being such that when an up solenoid is energised the valve 60 supplies oil along one of the ducts 61 to the bottom of the cylinder 40 of the corresponding ram so that the ram rod 41 is moved up and similarly when the down solenoid of a valve 60 is operated oil is supplied to move the ram rod 41 down.

In Figure 11 the moveable contact of each two way switch in each micro-switch 52 is shown engaging one or other of the stationary contacts in the position it normally occupies when the corresponding plunger 56 is not depressed. The conductor u or d of each two way switch which is thus connected to the supply through one of the conductors s leads to its corresponding solenoid in a valve 60 through a three-way eight-contact switch 62. It will be seen that the four normally live upper conductors from each two way switch, one corresponding to each of the rams A, B, C and D, lead to the four right hand contacts of the multiple switch 62 and these four contacts are normally open but are closed when the manual control member 63 is moved to the right hand chain-dotted position shown in Figure 11. Similarly a normally live down conductor d from the two way switches corresponding one to each of the four rams lead to the four left hand contacts of the multiple switch 62. These four contacts are also normally all open but may all be closed simultaneously when the control member 63 is moved to the left hand chain dotted position shown in Figure 11. In each two way switch of each micro-switch 52 then one of the conductors u or d is normally live but is disconnected from the corresponding solenoid of the corresponding valve 60 owing to the open contacts in the multiple switch 62. However, if the control member 63 is moved to its down or up position, current is supplied to the down or up solenoid respectively of all four valves 60 so that all four ram rods 41 are moved downwards or upwards respectively simultaneously. This is how the weight of the crane is taken on the four elephant feet 42 and the crawler tracks 22 are both raised off the ground prior to extending or retracting them laterally relatively to the bed plate.

If the bed plate has not been levelled prior to the track extension or retraction operation, the automatic levelling device will override the manual control member 63, to ensure that the bedplate is raised or lowered substantially level. The machine is then immediately ready for work at the new site, normally however the manual control member 63 is in its central neutral position shown in full lines in Figure 11 in which all the contacts of the multiple switch 62 are open. If the chamber 48 tilts sufficiently for the plunger 56 of one of the micro-switches 52 to be depressed, the moveable contacts of both the two way switches within that micro-switch 52 move to their

other limiting positions and engage the other stationary contact of the two way switches. The conductor *u* of one and the conductor *d* of the other of the two-way switches of each micro-switch which has been operated now lead, not through the multiple switch 62, but directly to the up solenoid of the valve 60 associated with a ram at one corner of the bed plate 16 and to the down solenoid at the valve 60 associated with the ram at the diagonally opposite corner of the bed plate 16. It will be seen by comparing the relative orientations of the rams around the bed plate 16 and of the micro-switches 52 around the chamber 48 that the rod of the ram at that corner of the bed plate 16 towards which the chamber 21, and hence the bed plate 16, has tilted is extended downwards and the rod of the diagonally opposite ram is retracted upwards so that the bed plate is relevelled and equilibrium is restored. As soon as the bed plate is levelled again so that the chamber no longer depresses one or more of the plungers 56, the moveable contacts in the two way switches revert to their normal position and the corresponding solenoids are de-energised until a further correction is necessary.

A master levelling device of the kind illustrated in Figures 9 and 10 is claimed in our copending Application No. 14914/66 (Serial 1048723). The device may be used additionally to give a visible or audible warning when the bed plate tilts beyond an acceptable angle in one direction or the other. In this case the micro-switches may be electrically connected to signal lights at each corner of the bed plate to indicate which is the lowest part of the bed plate, or connected to a gradient warning device so that the warning device is operated when the bed plate tilts through an unacceptably large angle in any direction.

WHAT WE CLAIM IS:—

1. A tower crane having a bed plate which is mounted on crawler tracks the frames of which, adjacent to the front and rear on each side of the bed plate, are raised and lowered relatively to the bed plate under the control of a master levelling device which ensures that when the crawler tracks follow the contours of the ground the bed plate is maintained substantially horizontal.

2. A crane according to claim 1, in which there is a single crawler track at each side of the bed plate, each track being supported by a flexible frame the front and rear parts of which are independently suspended from the bed plate and are interconnected by a pivotal link.

3. A crane according to claim 1 or claim 2, in which the crawler frames are suspended from the bed plate by means of beams which are pivotally connected to the bed plate and are rocked about their pivotal connections to raise and lower the parts of the crawler frames under the action of four separate levelling rams each of which acts between the bed plate and one of the beams.

4. A crane according to claim 3, in which the two beams through which the frame parts at the front of the bed plate on each side are suspended and the two beams through which the frame parts at the rear of the bed plate on each side are suspended, extend transversely across the bed plate and are all pivotally mounted to the bed plate at a common central pivotal axis extending longitudinally of the bed plate.

5. A crane according to claim 4, in which the beams are extendable so that the crawler tracks and frames can be moved laterally outwards away from the bed plate to a new working position or range of positions.

6. A crane according to claim 5, in which each beam is made in two telescopic parts: a hollow beam box which is pivotally connected to the bed plate and is acted upon by its corresponding levelling ram, and a beam axle which slides within the box and supports its corresponding crawler frame parts.

7. A crane according to claim 6, in which the extension of the beams is controlled by means of subsidiary rams each of which is connected between the bed plate and one of the crawler frames.

8. A crane according to claim 6 or claim 7, in which the beam boxes extend substantially the full width of the bed plate and carry at their ends, remote from the crawler frames which they carry, elephant feet on which the crane can be supported whilst the crawler frames are moved laterally outwards or inwards.

9. A crane according to any one of the preceding claims, in which the master levelling device comprises a chamber which is loosely universally mounted so that it can tilt in all directions on the bed plate and the inner bottom surface of which is inclined upwards and outwards in all directions from the centre of the bottom, a spherical ball which rests in the bottom of the chamber, and a number of micro-switches symmetrically arranged around the upright central axis of the chamber; the arrangement being such that when the bed plate is level the spherical ball rests in the centre of the base but when the bed plate tilts in one direction or the other the chamber tilts relatively to the bed plate in the same direction and the ball rolls outwards from the centre of the base and the added weight of the ball on that side of the chamber causes the micro-switch or switches to be operated in such a way that a levelling means actuated by the switches causes the crawler track frames to be raised or lowered relatively to the bed plate as necessary to level the bed plate.

10. A crane according to any one of the preceding claims, in which the main bed plate carries above it through a turntable a subsidiary upper bed plate on which is mounted a superstructure and a tower structure which carries a luffing jib.

11. A crane according to claim 1, substantially as described with reference to the accompanying drawings.

For the Applicants:
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London, W.C.2.

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Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

1048722 COMPLETE SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

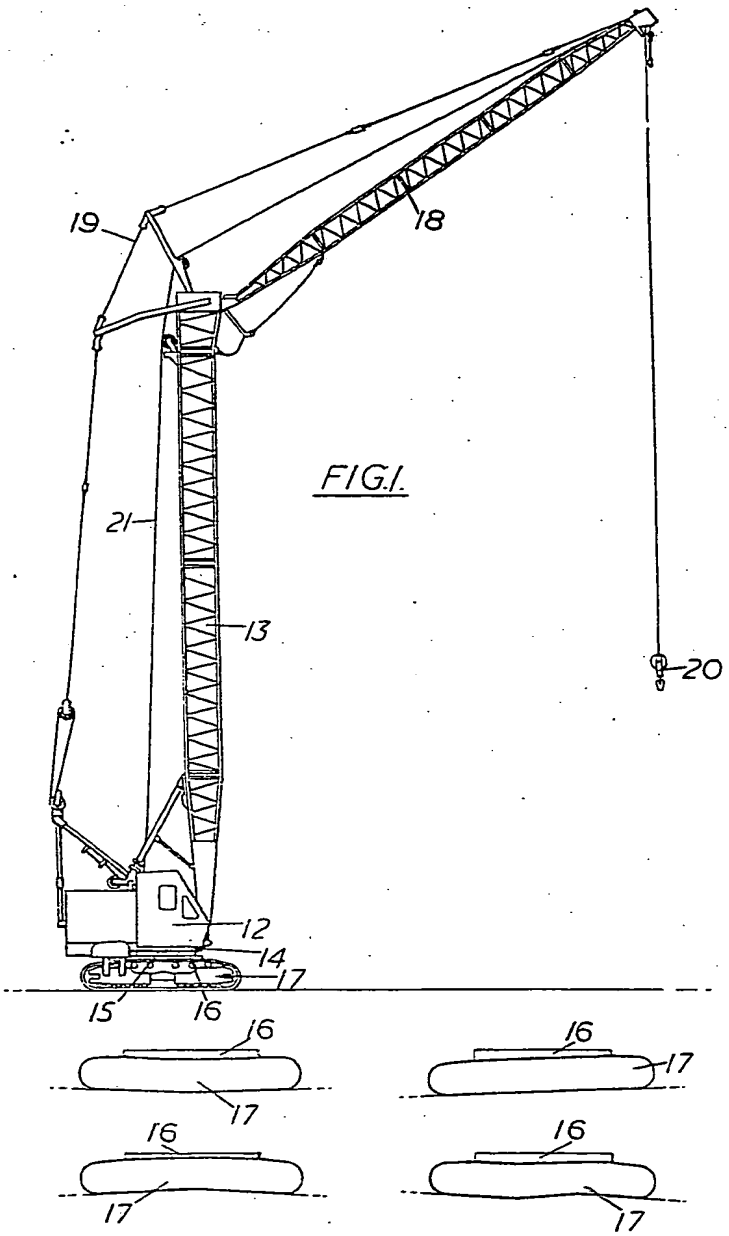
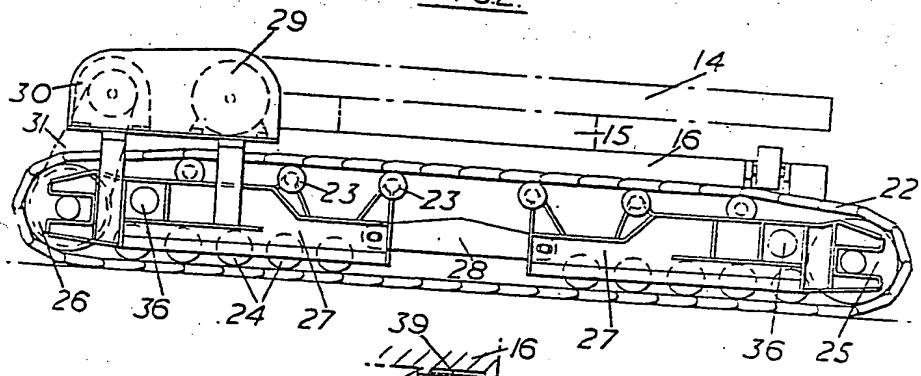


FIG.1.

FIG8.

FIG.2.



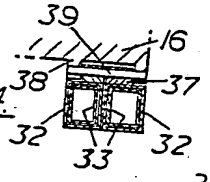


FIG.4.

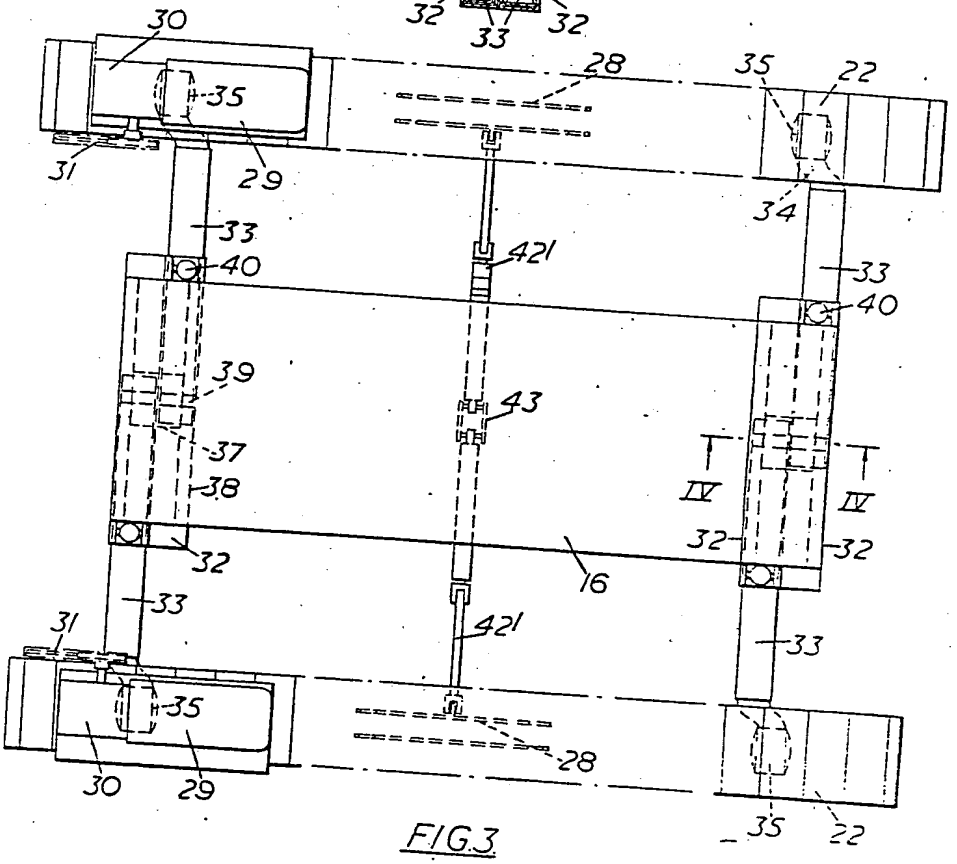


FIG.3

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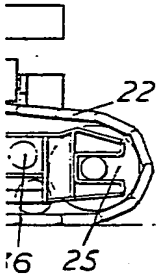
Sheets 2 & 3



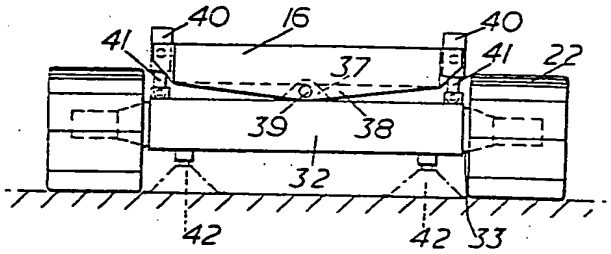
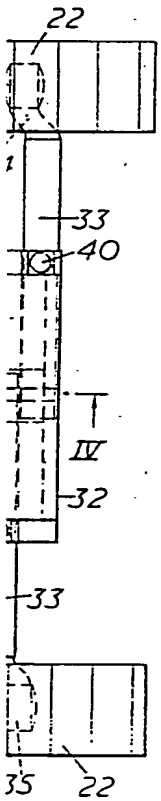


FIG.5.



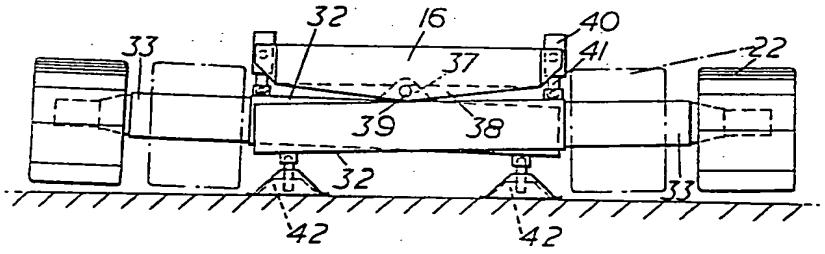


FIG.6.

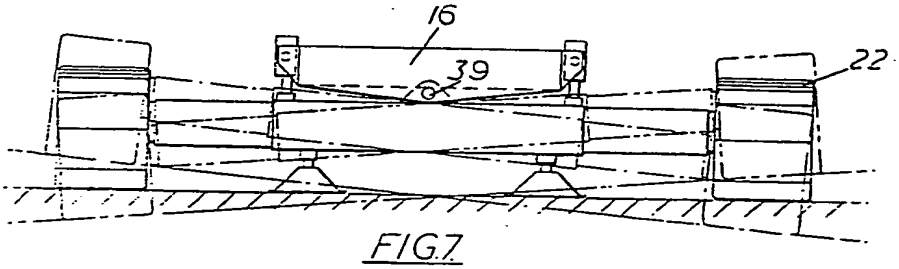


FIG.7.

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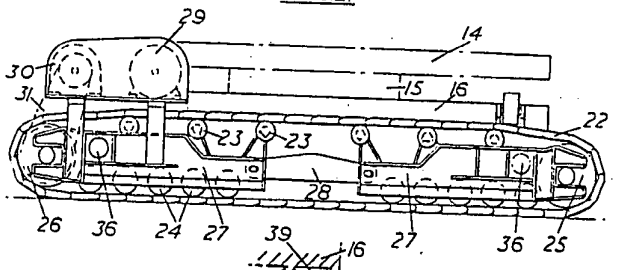
FIG.2.



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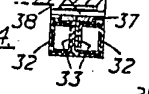


FIG.3.

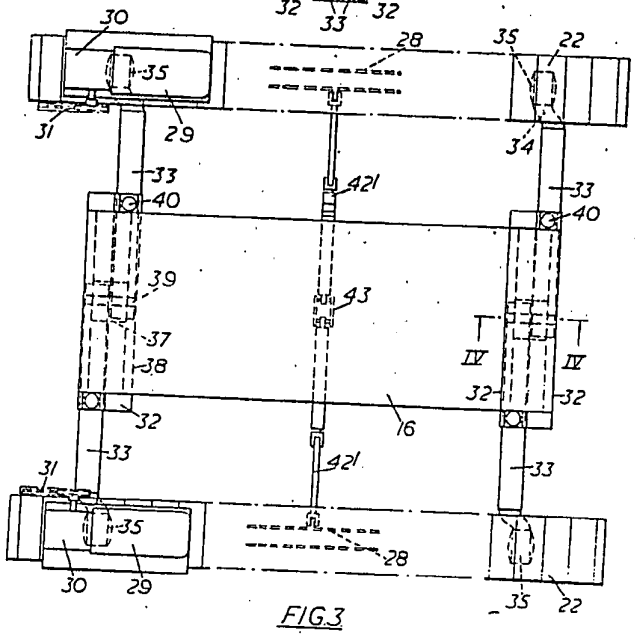


FIG.5.

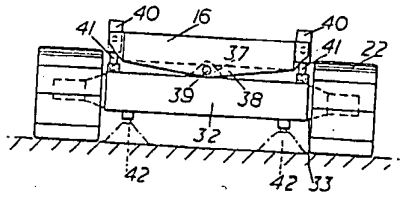


FIG.6.

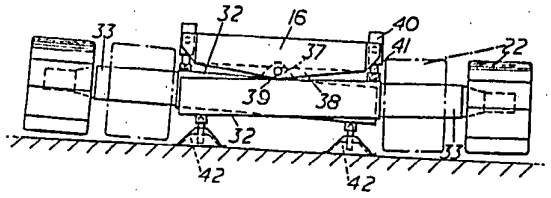
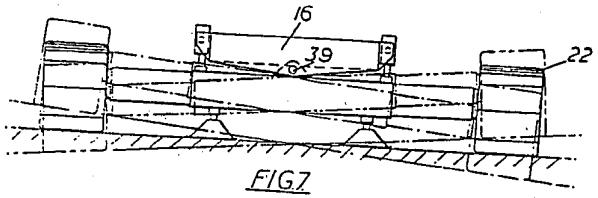


FIG.7.



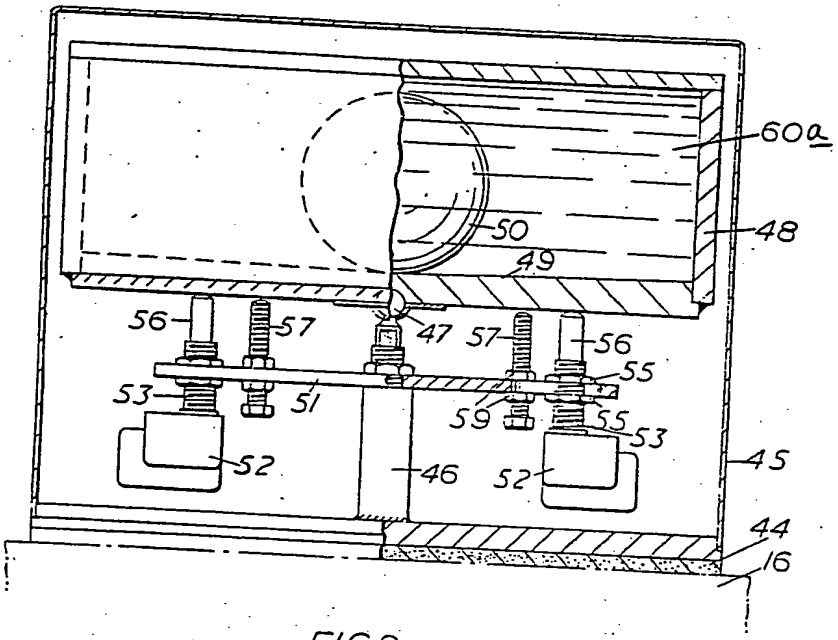


FIG.9.

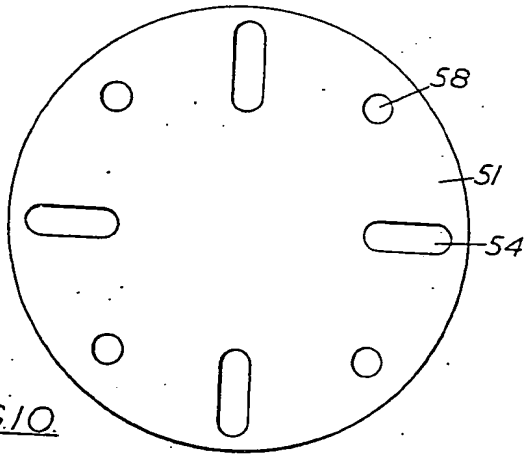


FIG.10.

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Sheets 4 & 5

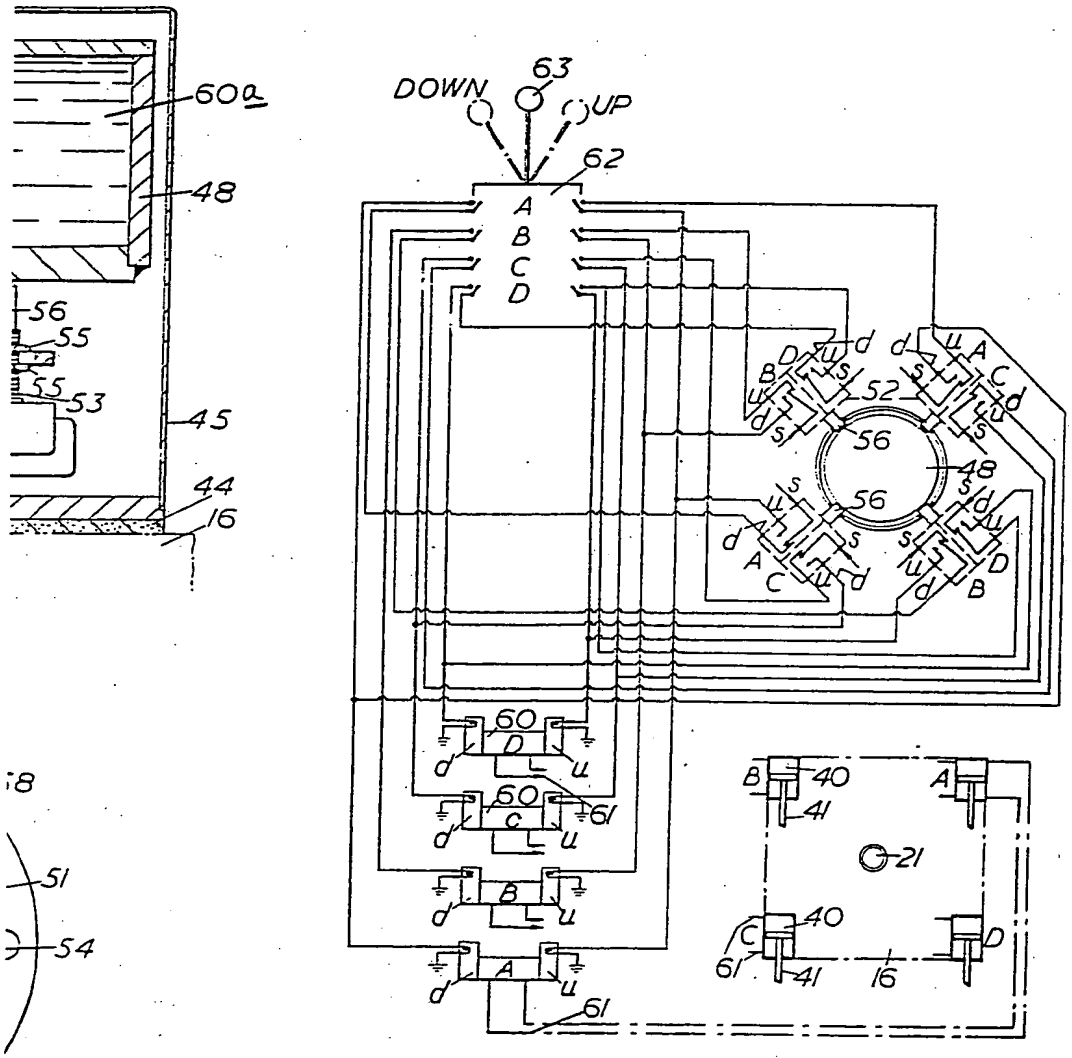

FIG.11

1048722 COMPLETE SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
Sheets 4 & 5

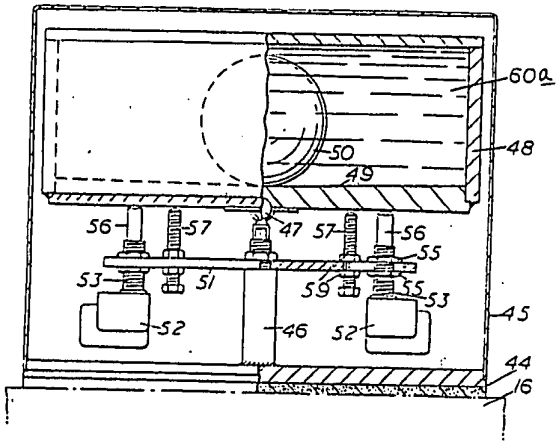

FIG.9.

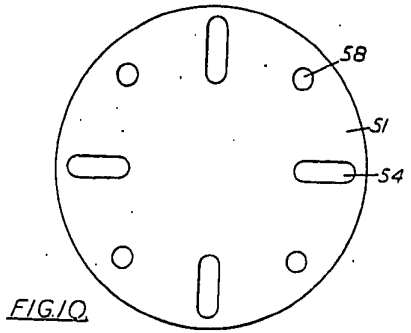

FIG.10.

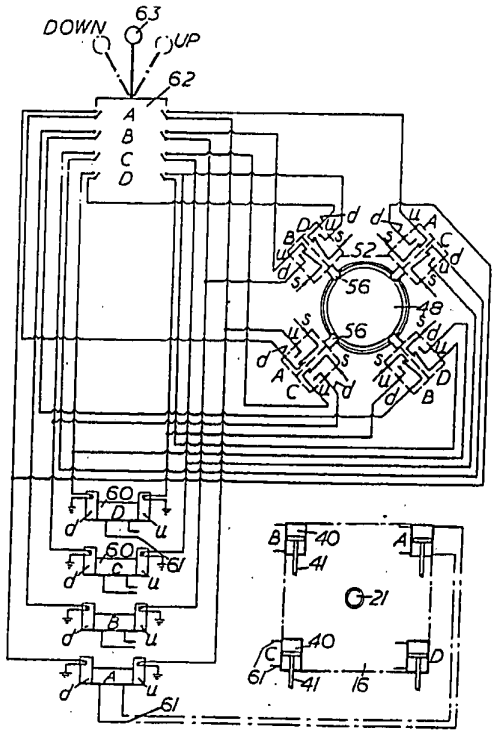

FIG.11.